California Division of Mines & Geology
Fault Evaluation Report FER-226

Notes on the Faults of the Truckee-Tahoe Area Placer, Nevada, and Sierra Counties, California

by Robert H. Sydnor
April 22, 1991

INTRODUCTION

Faults in the northern Lake Tahoe - Truckee area within the eastern portions of Placer, Nevada, and Sierra counties are evaluated in this Fault Evaluation Report (FER). This includes the Dog Valley fault, the North Tahoe fault, and numerous unnamed shorter faults in the Truckee area. The Truckee-Tahoe FER area lies within the eastern portion of the Chico 1:250,000 Sheet and includes these six 7½-minute quadrangles: Kings Beach, Tahoe City, Martis Peak, Truckee, Boca, Hobart Mills, Dog Valley, and Sardine Peak. These quadrangles are indexed in Figure 1.

Faults in the Truckee-Tahoe area are evaluated as part of a statewide effort to evaluate faults for recency of activity. Those faults determined to be sufficiently active (Holocene epoch) and well-defined are zoned by the State Geologist as directed by the Alquist-Priolo Special Studies Zones Act of 1972 (Hart, 1990).

The scope of this report is primarily an office review of pertinent literature and analysis of stereoscopic aerial photographs. A brief field reconnaissance was performed; portions of three separate days were spent in the field to review the Dog Valley fault zone and certain unnamed faults along the north shore of Lake Tahoe. Refer to Figure 2. This report is organized in a format which integrates 1989 field review comments into a chronological review of published literature. A summary evaluation is made pertaining to Holocene-active faults.

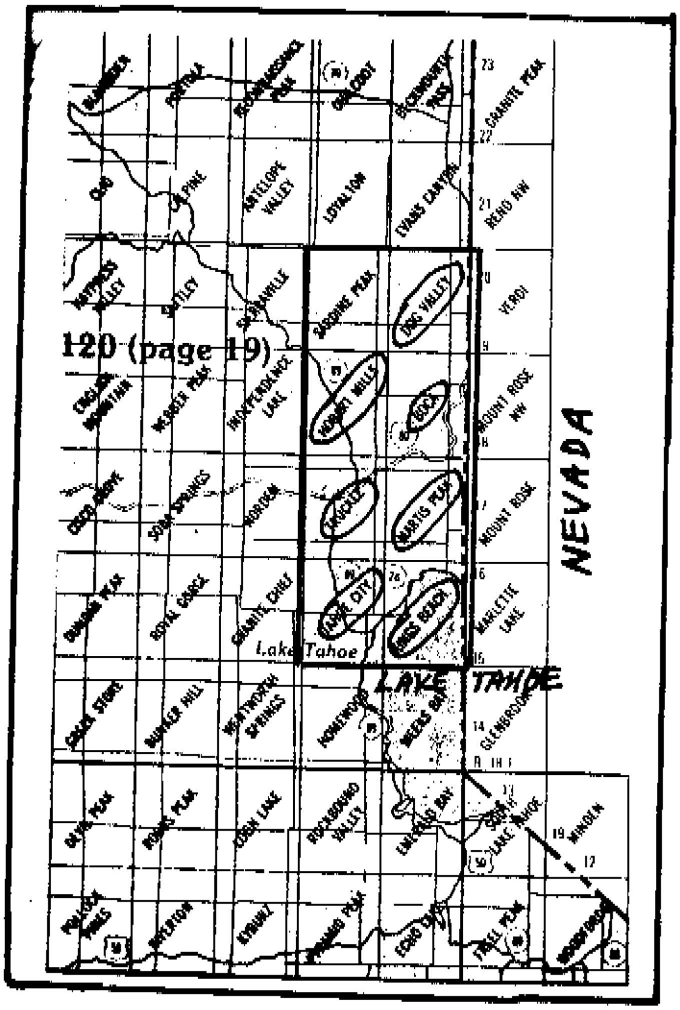


Figure 1.
Index Map of 7½-minute quadrangles within the reconnaissance area. Applicable quadrangle names are circled.

SUMMARY OF AVAILABLE DATA

The Truckee-Tahoe area is located in northern Sierra Nevada geomorphic province and near the western margin of the Basin and Range province (Figure 3). Lake Tahoe is a remarkably deep and unusually large alpine lake occupying a structurally controlled basin which developed during the Quaternary Period by active faulting (Louderback, 1911; Burnett, 1968 & 1971; Crippen and Pavelka, 1970; Harwood and Fisher, 1991). The Truckee-Tahoe area is seismically active (Goter, 1988; Ryall and VanWormer, 1968 & 1980; Wolfe, 1968; Lewis and Grose, 1988). Most of the Truckee area was glaciated during the Quaternary Period and glacial deposits conceal the granitic bedrock in many valleys (Birkeland, 1963, 1964, 1965, 1967; Birkeland and Janda, 1971; Burke and Birkeland, 1979; Kirk, 1974). There are also several Quaternary volcanic deposits in the area north of Lake Tahoe (Lindgren, 1896; Kimball, 1967; Latham, 1985).

Saucedo and Wagner (1992; in press 1991) have recently prepared a new compilation of the Chico 1:250,000 Quadrangle which covers the entire study area. When published in 1992, it will replace the earlier Chico Sheet by Burnett and Jennings (1962). A new state fault activity map is also applicable to the study area (Jennings, 1991, map currently in preparation); when eventually published it will replace the 1975 state fault map.

The topography within the study area ranges from hills with moderate relief near Prosser Reservoir to relatively steep mountain fronts and incised drainages of the Truckee River. Elevations vary from about 5,300 feet (1,600 m) along the Truckee River to a high point of 8,742 feet (2,665 m) at Martis Peak. Lake Tahoe has a maximum elevation of 6,228 feet (1,897 m) and is tenth deepest (1,627 feet or 496 m) lake in the world. Low hills and moderate relief (5,600 to 6,000 feet elevation) characterize the terrain of the Dog Valley fault in the vicinity of Prosser, Boca, and Stampede Reservoirs.

Heavy snow (2-4 m) typically covers the Truckee/Donner/Tahoe areas in the winter time. This seasonal snow cover tends to reduce potential evidence of young fault scarps and tectonic cracks within the regolith.

REVIEW OF GEOLOGIC LITERATURE

Fault-related literature for the Truckee and north Lake Tahoe region was reviewed for this report. Papers which have a special significance to active tectonism and seismicity are reviewed in the paragraphs below in approximate chronological order of publication. The focus of the papers is variable and includes topics in glacial stratigraphy, structural geology, volcanology, seismology, and engineering geology.

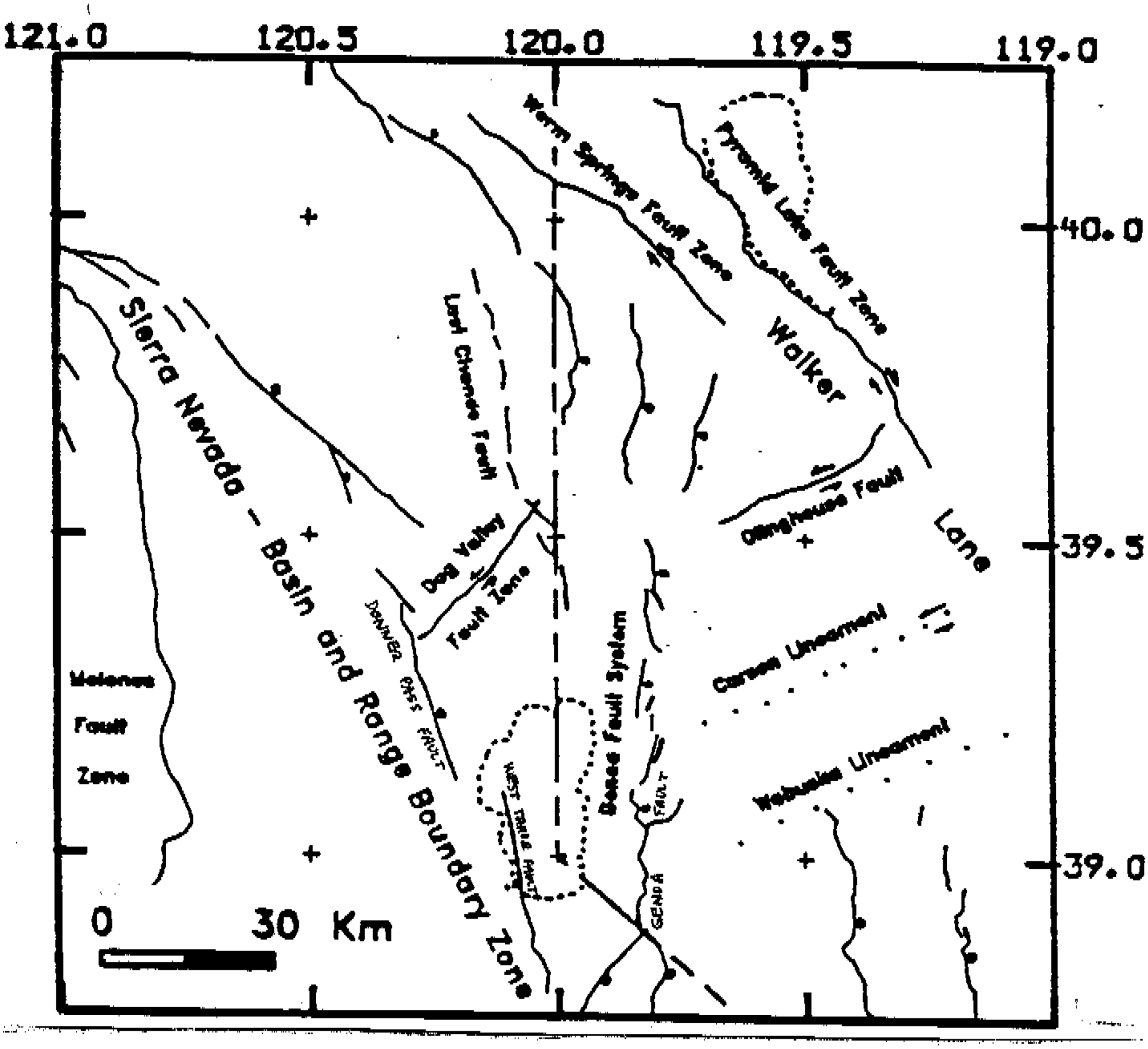


Figure 3. Sierra Nevada - Basin and Range Boundary Zone.

Major faults and lineaments are shown. Arrows indicate relative movement on strike-slip faults and balls indicate down-thrown blocks of normal faults. (From Figure 2b of Martinelli, 1989)

Review of Birkeland (1963) and the Truckee-Tahoe Regional Geomorphic Setting

After the early geologic mapping of Lindgren (1896) and Hudson (1948 and 1951), the first definitive modern work in the Truckee area was done by Birkeland as a doctoral thesis at Stanford in 1961 and published in GSA Bulletin in 1963. The small-scale geologic map in Birkeland's report remains a basic reference for all later work.

Birkeland focused his work on the Pleistocene volcanism and deformation in the Truckee Canyon area. His map covers the area between Boca Reservoir and the northwestern margin of Lake Tahoe. Birkeland carefully mapped the Pleistocene volcanic rocks and all four stages of the Pleistocene glacial deposits (Tioga, Tahoe, Donner Lake, and Hobart tills). Revised ages of these glacial tills are determined by Coleman and Pierce (1981) based on relative development of weathering rinds on basaltic rocks within the tills. A Quaternary stratigraphic column of the Truckee region is provided in Figure 4.

Quaternary investigations in the Truckee/Tahoe region have relied heavily on Birkeland's work as a framework for the complex stratigraphic relationships. Birkeland's mapping area was principally in the Truckee River valley; it did not extend north of the Boca Reservoir/Prosser Creek area, so he did not study the Dog Valley fault at its type locality, nor the central portion of the Dog Valley fault in the vicinity of Russel Valley.

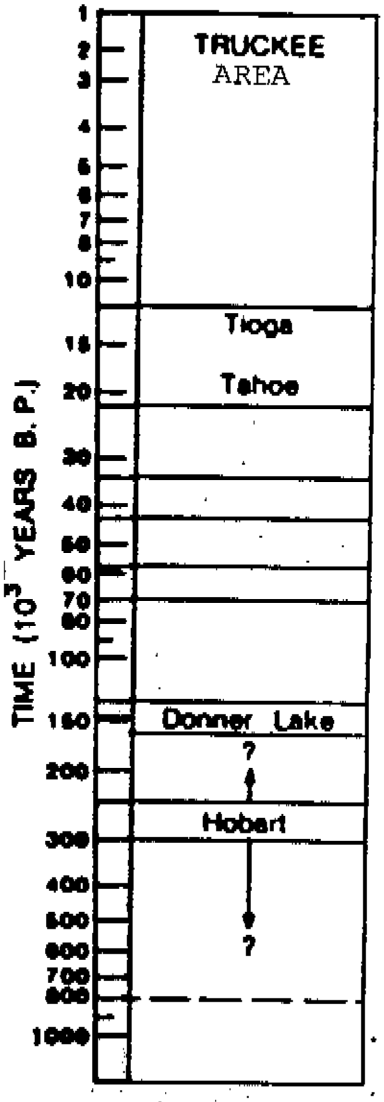
Birkeland recognized that the Pleistocene volcanic vents extruded their flows over a topography that was somewhat similar to today. The Pleistocene volcanic flows postdate the major part of the Pliocene-Pleistocene deformation of the Sierra Nevada and appear to predate the oldest recognized glaciation in this part of the Sierra Nevada. Large-scale deformation followed Pleistocene volcanism.

Birkeland (1963, p. 1461) reports that "the faults in the Truckee area are steeply dipping normal faults, most of which are oriented between north and northwest, parallel to the regional trend of late Cenozoic faults. Vertical displacements, based on the offset of flow surfaces, range from about 100 to 700 feet. With two exceptions the block on the basin side of the fault was down-dropped relative to that of the range side. These two exceptions are the antithetic faults located 2-3 miles southeast of Truckee [in the Martis Creek area]."

Birkeland (1963, p. 1453) states that "all [fault] movements appear to predate the oldest recognized glaciation" [in the Truckee area]. This apparently includes the Hobart glacial deposits which are believed by later workers (Coleman and Pierce, 1981) to be about 250,000 to 300,000 years old (refer to Figure 4). Birkeland summarizes (p. 1462) by stating that "the major features of the landscape appear to have been formed in the late Pliocene to early Pleistocene with the formation of the Lake Tahoe Basin by faulting and the Truckee Basin by both faulting and warping."

Figure 4.

ESTIMATED AGES OF GLACIAL DEPOSITS IN THE TRUCKEE AREA
(after Coleman and Pierce)



modern alluvial and colluvial soils developed on Pleistocene glacial deposits and granitic bedrock.

beginning of Holocene Epoch, 10,000 ybp

circa 12,000 ypb

these deposits may be related

circa 22,000 ybp

circa 140,000 ybp

circa 160,000 ybp

circa 250,000 ybp

circa 300,000 ybp

relative age of glacial deposits by Coleman and Pierce

one million years before present(ybp)

Modified from Coleman and Pierce (1981), fig. 21, p. 33.

Review of Kachadoorian and others (1967) and the M_w5.9 Truckee Earthquake of September 12, 1966

A significant earthquake centered near Boca Reservoir (about 11 km northeast of Truckee) occurred on September 12, 1966. It was widely felt throughout the northern Sierra Nevada - Lake Tahoe - Reno area. Initial estimates of the magnitude were M_L5.4 by the USC&GS and M_L6.1 by the University of California at Berkeley. Later determination of the seismic moment of 0.83×10^{25} dyne-cm by Tsai and Aki (1970) yields a moment magnitude herein calculated to be M_w5.9. These magnitude values are of particular interest because they are near the threshold relationship between the expected occurrence of surface rupture and a minimal magnitude. The 1966 Truckee earthquake had a focal depth of about 10 km, which is considered to be "moderate" depth (being neither unusually shallow nor particularly deep).

There are three significant earthen dams in the epicentral area, so the earthquake was of immediate concern to both engineering geologists and seismologists. In the three days following the 1966 earthquake, a 3-man team from the U.S. Geological Survey quickly investigated the surface effects (Kachadoorian and others, 1967). Their brief but cogent 14-page report is the basis for most of our knowledge of the surface effects and is selectively quoted in the following paragraphs.

"Ground breakage due to seismic shaking occurred in unconsolidated alluvium along a zone about 10 miles ($\approx$ 16 km) long that trends about N30°E and extends from a point west of Prosser Reservoir, 4 miles north of Truckee, to Hoke Valley. The concentration of ground breakage along this zones suggests that it may be related to a subsurface northeastward-trending fault rather than to buried extensions of the northwestward-trending faults that dominate the regional geologic structure." (Kachadoorian and others, 1967).

Their location map of ground breakage is shown in Figure 5. "Broken ground, slumping and fissuring of natural and artificial fill, and rock falls were found along a zone trending north-northeast about 5 miles wide and 10 miles long in the Russel Valley area. Minor but extensive ground breakage occurred in a zone about 10 miles long that trends about N30°E; the zone ranges in width from about 75 feet near Prosser Reservoir and Hoke Valley to about 1 mile in Russel Valley. Ground breakage was confined to low elongated areas of unconsolidated natural fill, commonly subparallel to the zone, The breakage is expressed locally as cracks, slightly sinuous small ridges, wedges, and mounds of freshly disturbed soil and turf; the linear features are commonly oriented subparallel to the zone and are as much as 20 feet long. Pebbles were locally overturned. *All these effects are attributed entirely to shaking* but are in no case associated with lateral spreading of the ground toward an unconfined face. They may be, however, associated with the effects of topography on the passage of gravitational waves."

"Alinement of the zone of ground breakage with the trend of the fault exposed at the Stampede damsite suggests an association with the fault; however, *a thin veneer of undisturbed soil overlying the fault trace indicates that movement did not occur here during the earthquake.*" (Kachadoorian and others, 1967, p. 3-4; italics are added).

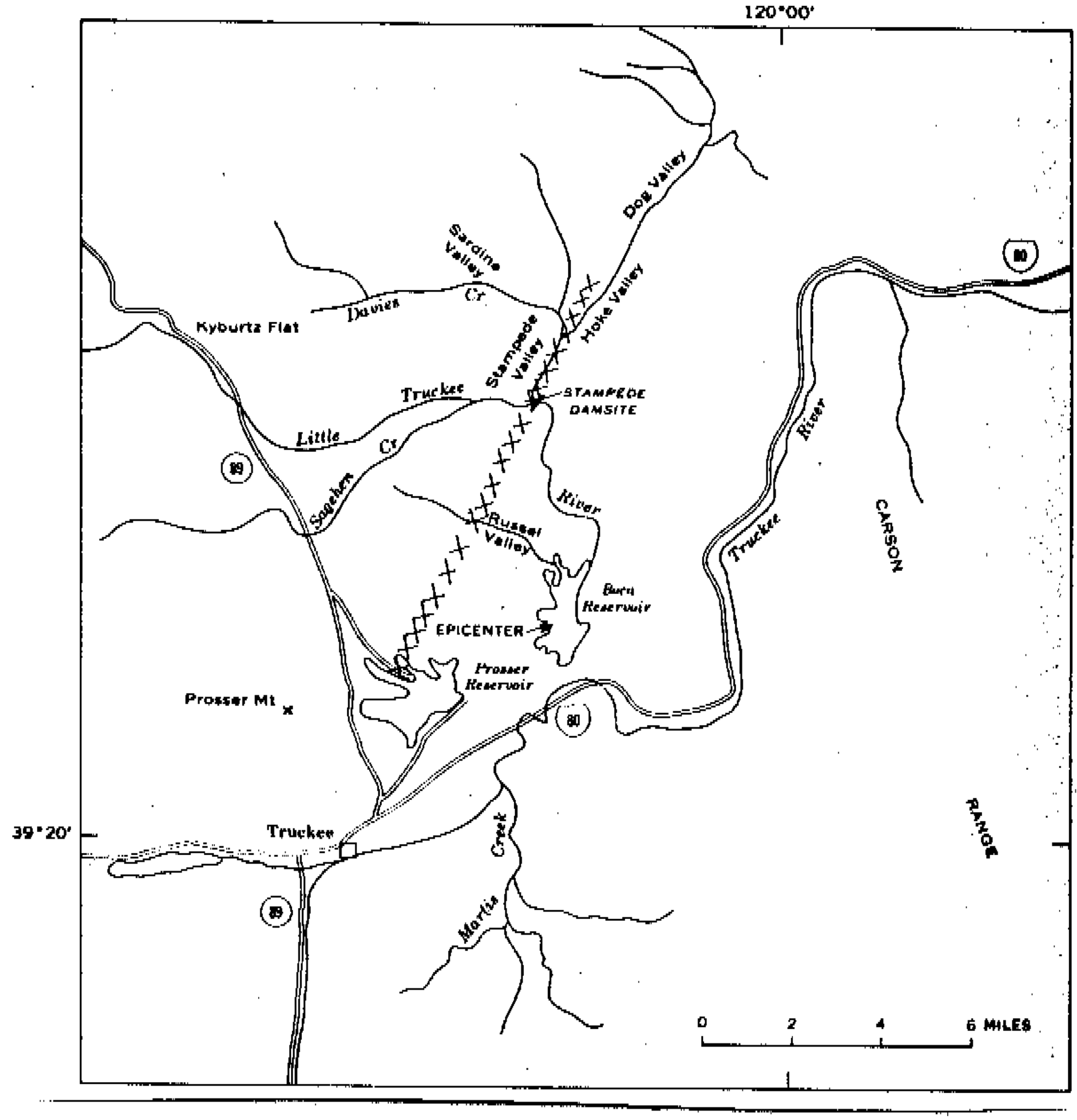


Figure 5. Index Map of 1966 M_L5.4 Truckee Earthquake.

This figure is from Kachadoorian and others (1967). Map scale is 1:250,000. The X-pattern indicates the approximate zone of ground breakage. At this scale the X-pattern is about 600 meters in width. Circular 537 does not contain a larger scale map than this depiction of ground breakage.

Prosser Dam sustained some cracking along and parallel to its crest. Boca Dam sustained minor cracking; it was located 3 miles from the zone of ground breaking. Within the Truckee area, there was widespread but minor damage to highway bridges, the Southern Pacific Railroad lines (rockfalls), and plaster cracks and fallen chimneys in many homes. There were no fatalities.

A 1974 CDMG field reconnaissance of the 1966 Truckee earthquake epicentral area was performed by David L. Wagner for preliminary evaluation for purposes of both the Alquist-Priolo program and the State Fault Map. He was "unable to identify any fault-related features on the ground, although a good lineation can be seen on an aerial photograph." (Wagner memo to E.W. Hart, 7-31-74). The ground cracks resulting from the 1966 earthquake were 8 years old at the time of the 1974 inspection. The epicentral area sustains about 2 to 5 m of winter snowfall and the evidence of ground cracking is diminished with each successive snowfall. Additional CDMG field reconnaissance in October 1989 to search for these seismically-induced ground cracks was after 23 winter snowfalls, so the opportunity for reliable observation of subtle cracking was diminished accordingly.

The prompt geologic reconnaissance report of Kachadoorian and others (1967) contained only preliminary seismological information for the 1966 Truckee earthquake. Ryall and others (1968) were the first seismologists to publish, followed shortly by Greensfelder (1968). Two years later Tsai and Aki (1970) corrected and revised some of the seismological parameters published in first two papers. The 1970 paper appears to be the most accurate in regards to seismological data, and these data are cited herein.

The principal nodal plane has a strike of N44°E, dip 80°SE. This is similar to the N30°E trend for ground cracking reported by Kachadoorian and others (1967). The seismic moment is used by Tsai and Aki (1970) to give a minimum estimate of about 30 cm for the average dislocation of the fault at the hypocenter. No evidence for this amount of offset was observed on the ground surface by Kachadoorian and others (1967). The focal depth was 10 km and apparently fault rupture did not propagate to the surface from this M_w5.9 event.

Review of Hyne and others (1972) and faults of Lake Tahoe Basin

The Quaternary history of Lake Tahoe was studied using marine seismic reflection survey methods by Hyne and others (1972). They recognized that "the boundary faults [of the down-dropped graben] are *probably active* and fault scarps occur in the most recent [Holocene] sediments in Lake Tahoe..." (italics added).

The bottom of Lake Tahoe is remarkably flat at about 450 meters in depth and submarine contours indicate that the lake is structurally a parallelogram pull-apart basin with east and west sides trending about N-S, and north and south sides trending about N40°E. Refer to Figure 6.

"The steep east and west sides of the basin have been interpreted as fault scarps (or fault-line scarps) on the basis of physiography and other evidence summarized by Burnett

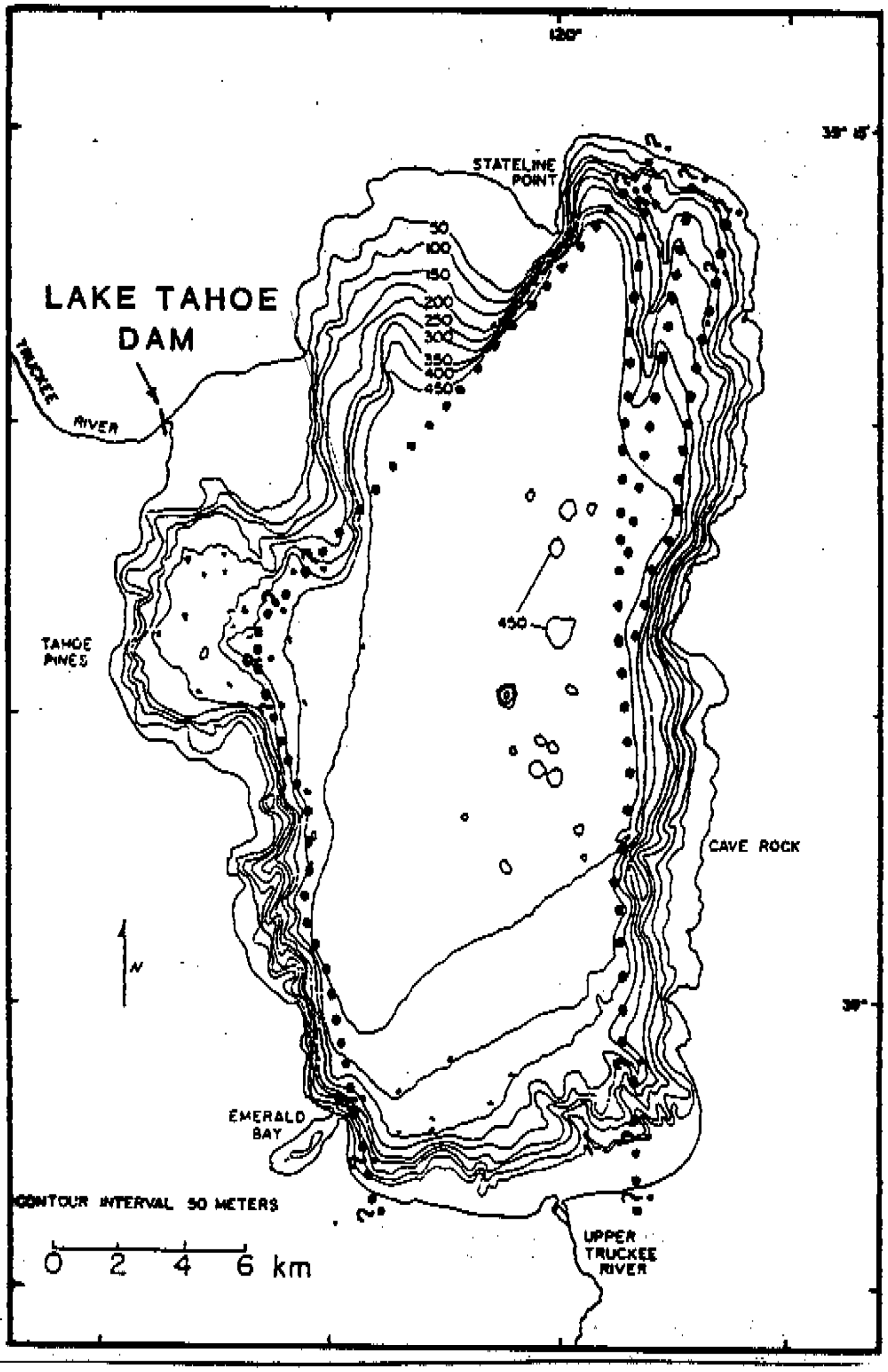


Figure 6. Bathymetric map of Lake Tahoe.

After Hyne and others (1972), modified by Hawkins and others (1986, figure 5-1). The location of the inferred locations of Tahoe faults are shown for both the California (west) and Nevada (east) sides of the lake. Faults are dotted where concealed and querried where their location or extent is uncertain. Note the steep sides and flat floor of the lake.

(1971). Evidence for fault displacement along the basin sides is not seen in the seismic reflection profiles although the data are compatible with a fault origin for the basin. Individual faults are difficult to trace on land, in part because of the glacial sediment cover." (Hyne and others, 1972)

Off the northern shores of the lake, a large fault scarp is inferred from the steep (45°) escarpment trending southwest. Faulting is also indicated by the steep slopes of the submerged ridge extending 4 km into the lake to the east [Nevada side] of the large fault scarp." (Hyne and others, 1972, p. 1438)

"Seismic reflection profiles along the northern portion of the basin show considerable evidence of tectonic activity. The east face of the subaqueous ridge extending south from Stateline Point [Nevada side] strongly suggest a fault scarp." (Ibid, p. 1440).

South of Dollar Point [in California] evidence for faulting "is seen in an escarpment 14 m high *cutting the most recent sediments*" (italics added). This appears to be a tectonically active growth fault because the "fault displacement increases with depth in the sediments indicating that faulting has been continuous during deposition of the sediments and is still active." (Ibid, p. 1440)

On the basis of the intriguing description by Hyne and others (1972), a brief field inspection was made on October 9, 1989 of the inferred fault line north from Dollar Point, through the west side of the Chinquipin resort, and north across State Highway 28 towards the Carnelian Bay residential suburb. Refer to Figure 7 which shows the Dollar Point area. Every crossing of a paved road was checked. A slope profile was measured 50 meters north of State Highway 28 crossing. No vestige of a fault scarp was indicated there. The slope profile was a regular concave surface which lacked anomalous inflection points.

There is submarine evidence for an active growth fault south of Dollar Point from the seismic reflection profile of Hyne and others (1972, their figure 9). Some of the submarine evidence for fault scarps is complicated by submarine landsliding along the steep scarp. It is postulated that landslides under Lake Tahoe are triggered by episodic earthquakes in the range of M5-M6+.

In summary, Hyne and others (1972) provide sub-lacustrine evidence for active Holocene faulting along the west and north sides of Lake Tahoe. The western boundary fault apparently does not extend onto land.

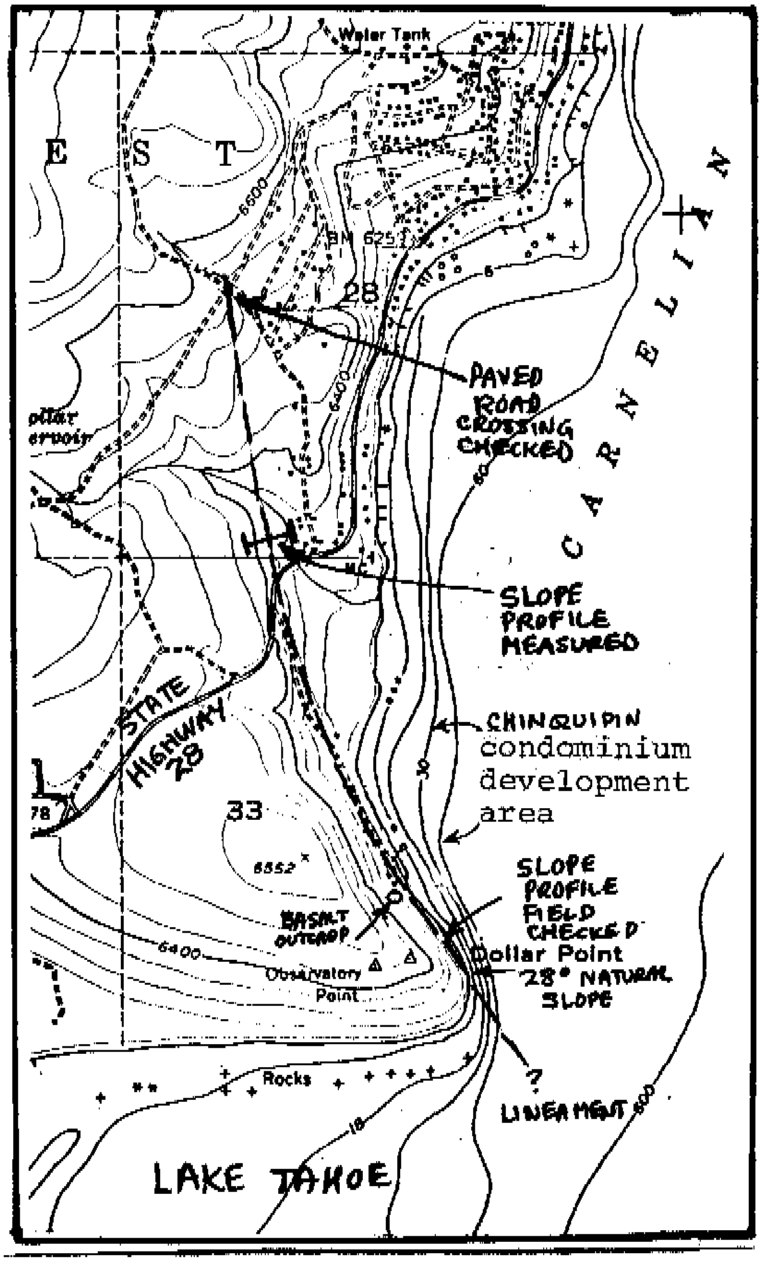


Figure 7. Index Map of the Dollar Point area, Carnelian Bay, north shore of Lake Tahoe. Scale 1:24,000. A fault has been mapped here by Burnett (CDMG unpublished map) and several others based on a prominent topographic lineament trending NNW from Dollar Point. It was field-checked for this FER on October 9, 1989 at seven locations along road access points and along the trail to Dollar Point. No scarps indicating Holocene activity were found.

Review of Gasch (1974) and faults near the town of Truckee

The Tahoe Forest Hospital in Truckee planned a structural addition in 1974-75. The Hospital Safety Act of 1972 had taken effect just prior to the planned addition, so a complete geologic and seismic hazards investigation was undertaken. This was among the first dozen of its type in the state and it broke new ground, so to speak. The engineering geologist and geophysicist was Jerrie Gasch of Gasch and Associates, Rancho Cordova. The project began in December 1973 and field work was performed in adverse winter conditions in January and February 1974; from photographs it is evident that there was several meters of snow on the ground. Although the field implications of winter conditions were not discussed by Gasch, this deep snow cover would substantially hinder a full review of the tectonic geomorphology and soil stratigraphy of the Truckee area.

Gasch had the USGS circular of Kachadoorian and others (1967), so he was justifiably concerned with the evidence of the 1966 M_w5.9 Truckee earthquake which had occurred 7½ years earlier. CDMG was just entering a new phase of review work for hospital sites under the leadership of the (then) new State Geologist, James E. Slosson. CDMG reviewers included Perry Amimoto, Earl Hart, and William Genthe.

Several CDMG meetings were held with Gasch and other design professionals retained by the hospital. Evidently, there was some iterative field work combined with these office meetings with state officials because Gasch wrote two documents in succession with a third document as an addendum letter.

The field methods of tectonic geomorphology was in its infancy circa 1974, although Gasch evidently made considerable effort to obtain geophysical field data, borehole data, and backhoe trenching across suspected fault traces. Gasch specializes in engineering field geophysics and that approach was applied both at the hospital site and along the trace of the Dog Valley fault. We submit this analysis of Gasch's work:

1. The use of Birkeland's seminal published work (1963 and following) is apparently lacking.

2. The use of aerial photographs and interpretation of lineaments was minimal. Regional lineaments were not plotted. The Dog Valley fault was drawn as a continuous line with a straight ruler for at least 13 miles, stopped only by the edge of the paper; see plate 2 of Gasch. A high-precision, low-accuracy location of the fault was made using a small-scale map for transfer onto a large-scale site map. The result was that the fault was projected at a distance of precisely 15 feet from the existing hospital foundations.

3. Extensive field geophysics was performed: gravity, magnetics, seismic wave-front geophysics (downhole methods), and seismic refraction. Surprisingly, the bedrock geology, the surficial glacial deposits, and the topographic profile were not added to the geophysical profiles to generate what is the ultimate goal: a geologic cross section. In

some localities near Russel Valley, a magnetic profile crossed a large-diameter steel petroleum pipeline, yet the obvious source for the subsurface magnetic anomaly was not plotted.

However, the ground magnetic survey in the Russel Valley area indicated "a relatively consistent anomaly" approximately 600 feet wide along portions of the traverse over the known "zone of ground breakage" [as mapped by Kachadoorian and others, 1967]. This appears to be possible evidence of a bedrock fault zone, however enigmatic it is at the ground surface.

4. A backhoe trench 385 feet in length and 5 feet deep was excavated across the hospital addition site. The floor of the trench was a hard cemented volcanic mudflow (65 feet in thickness) which could not be excavated by the particular backhoe used. This unit was apparently unfaulted, at least in a vertical sense. This appears to be cautious evidence that there is no Holocene faulting near the Truckee hospital.

5. Wave-front seismic survey methods were performed in 11 boreholes in the vicinity of the hospital. These provide secondary (inferential) evidence that there may be a fault zone or some structural discontinuity at depth.

In summary, the geophysical work of Gasch (1974) was a contribution to our understanding of geophysical properties of regolith and bedrock units near Truckee. He apparently did not locate definitive evidence of Holocene faulting. Therefore, CDMG has no cause for Alquist-Priolo zonation in the Truckee area based on this particular work.

USBR work by Hawkins and others (1986) was not aware of Gasch's 1974 report (RHS telephone call to Hawkins, 12-11-90). It is our judgement that the consulting report of Gasch (1974) would not have influenced Hawkins and others (1986) one way or the other; the later USBR work appears to be thorough, definitive, and not dependent on the work of others.

Review of Franks (1980) and the Faults of Martis Valley Area

West Martis Creek

A very thorough doctoral dissertation by Alvin L. Franks (1980) was prepared for the West Martis Creek drainage area, located about 8 to 10 km southeast of Truckee. His emphasis was on sedimentation and erosion control for a proposed subdivision, rather than neotectonics. (No fault trenching was done within the scope of his work.) His detailed geologic map (see Figure 8) covering about ten sections is at a scale of 1:12,000, and his custom topographic base map was better than an enlarged version of the USGS quadrangle.

Franks mapped four faults in the West Martis Creek area which he numbered 1 through 4. (Refer to Figure 8.) Three faults appear to be late Quaternary in age, but Fault No. 2 was described by Franks as being "Recent" in age (that is, Holocene). All of these faults were carefully reviewed on 1977 color stereoscopic aerial photographs (USDA Flight 377, numbers 188, 189, 190).

Fault #2 is apparently a high-angle fault which trends N60°E and apparently offsets the lake beds member of the Coal Valley Formation of upper Pliocene age. Holocene lake beds are ponded in a small valley against the fault scarp. The northwest side of the fault is relatively "up". The northern end of Fault #2 was briefly field-checked about 6:30 PM on October 9, 1989, but lack of adequate sunlight precluded a foot traverse of the entire fault which is about 2.6 km long.

Analysis of the aerial photographs indicates that fault #2 is not well enough defined to be a Holocene fault. Young geomorphic expression ~~is~~ appears lacking. These airphotos were independently checked by W.A. Bryant, who reached the same conclusion.

The other three faults as shown in Figure 8 appeared to be of Pliocene/ Pleistocene age, or at least older than the Holocene epoch.

On-site field review in the southwest corner of Section 30, T17N, R17E would be useful (at a subsequent phase of work) to corroborate our preliminary opinion about the relative age of Fault #2. Our preliminary opinion is that it is a late Pleistocene fault.

East side of Martis Valley

An unnamed fault near the historic Old Joerger Ranch on the east side of Martis Creek is about 5 km (3 miles) in length and trends north-south. Refer to Figure 9 for an index map modified from Birkeland (1963). It is evidently a significant high-angle normal fault with the east side (hills) relatively "up", and the west side (Martis Valley) "down."

The fault is discernable on aerial photographs (USDA flight 477, numbers 40-41-42-43). The scarp-like cliff in the center of the photograph appears to be a quarry face, perhaps related to pre-1977 earthwork of the dam abutment. No well-delineated Holocene scarp occurs at the mouth of the creek which exits Dry Lake, but the 1977 photos indicate that this area was substantially graded in the course of construction of the Martis Creek dam. South towards the site of the Joerger ranch house, the scarp is faint, being only the linear front of the hills to the east. The north end of the unnamed fault appears to terminate against or be

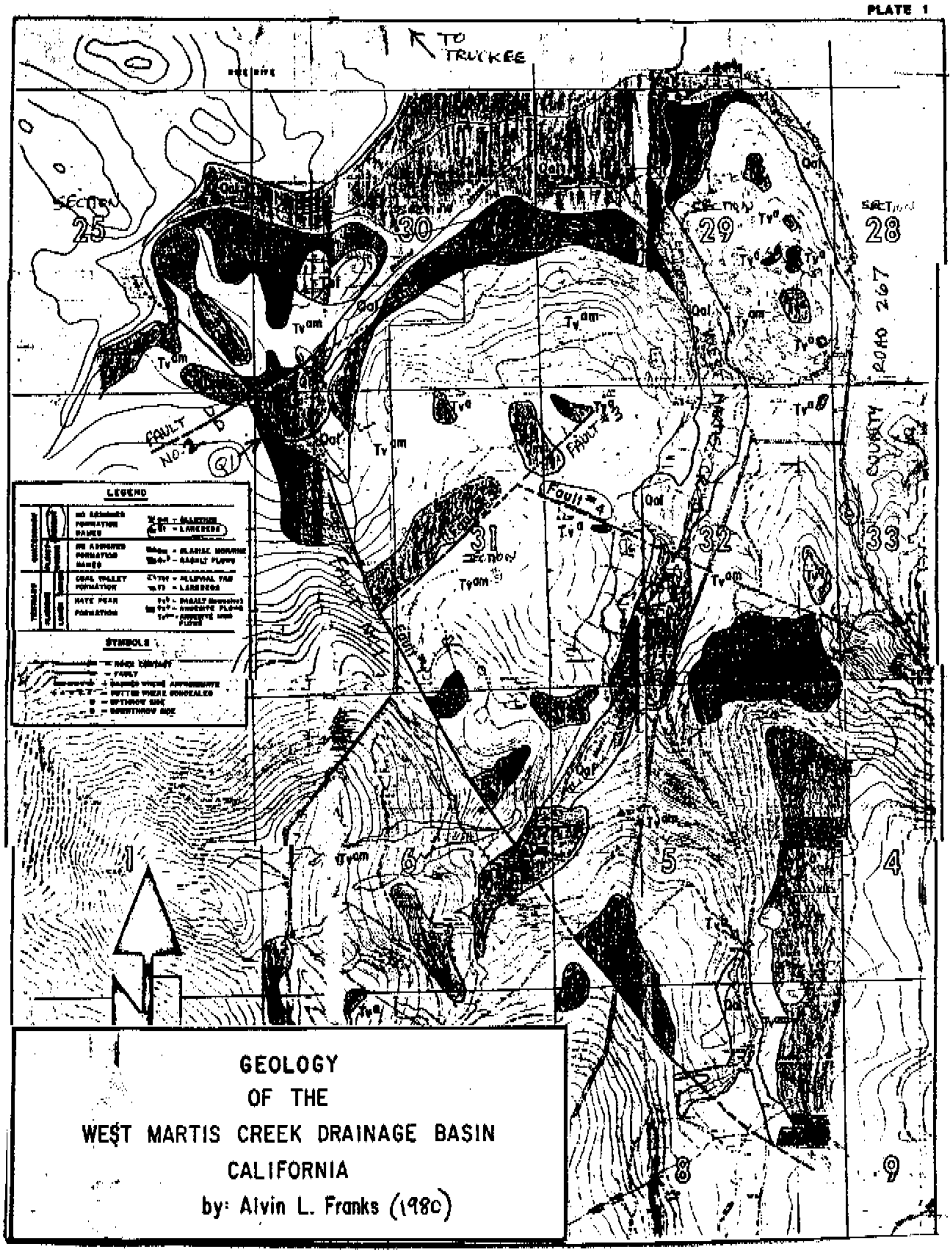


Figure 8. Faults of West Martis Creek area

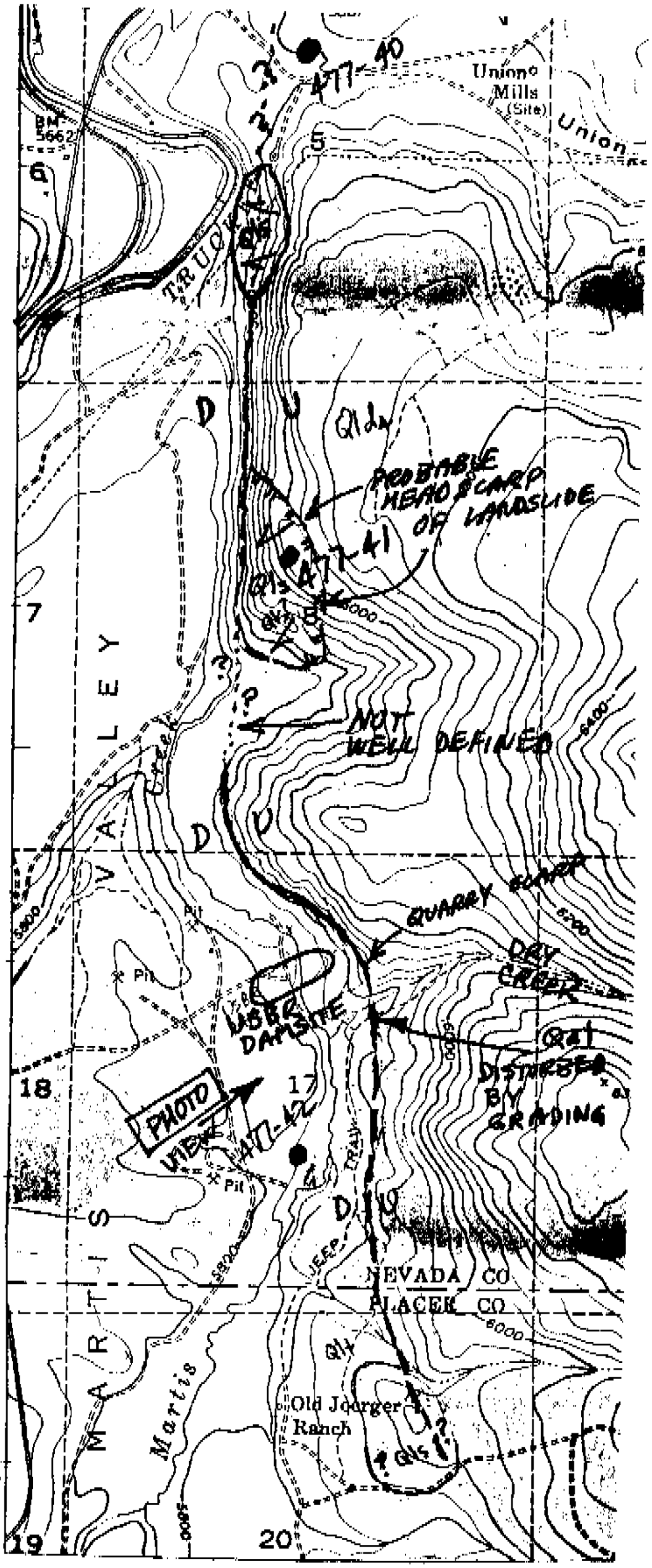


Figure 9.

INDEX MAP

East side of Martis Valley
Martis Peak quadrangle

see accompanying text

477-41 is location of photo center

USBR damsite

location of field photo

the fault scarp was not walked-out; this is recommended for the next possible phase of field work.

Old Joerger Ranch (site)

buried by the unfaulted late Pleistocene beds of the Hirschdale olivine latite of Birkeland (1963, fig. 5).

In summary, this unnamed fault appears to have significant Pleistocene displacement for the development of Martis Valley, but the evidence for Holocene displacement is lacking.

Review of Hawkins and others (1986) and reconnaissance of the Dog Valley fault zone

The most pertinent and comprehensive reference for the neotectonics of the Truckee - Lake Tahoe area was prepared by a team of geologists and seismologists from the U.S. Bureau of Reclamation (USBR), Denver. The purpose of their work focused on the safety of four dams in the Truckee - Tahoe area. The extensive project took about four years and included a complete review of all previous literature, trenching along the Dog Valley fault zone in two locations, monitoring of a special seismograph network designed for the inferred location of the Dog Valley fault, analysis and correction of locations of previous epicenters, and a study of the regional seismotectonic setting. The USBR study included information from both California and Nevada sides of the Tahoe region. This fault evaluation report relies on the USBR report as a principal source of current neotectonic information.

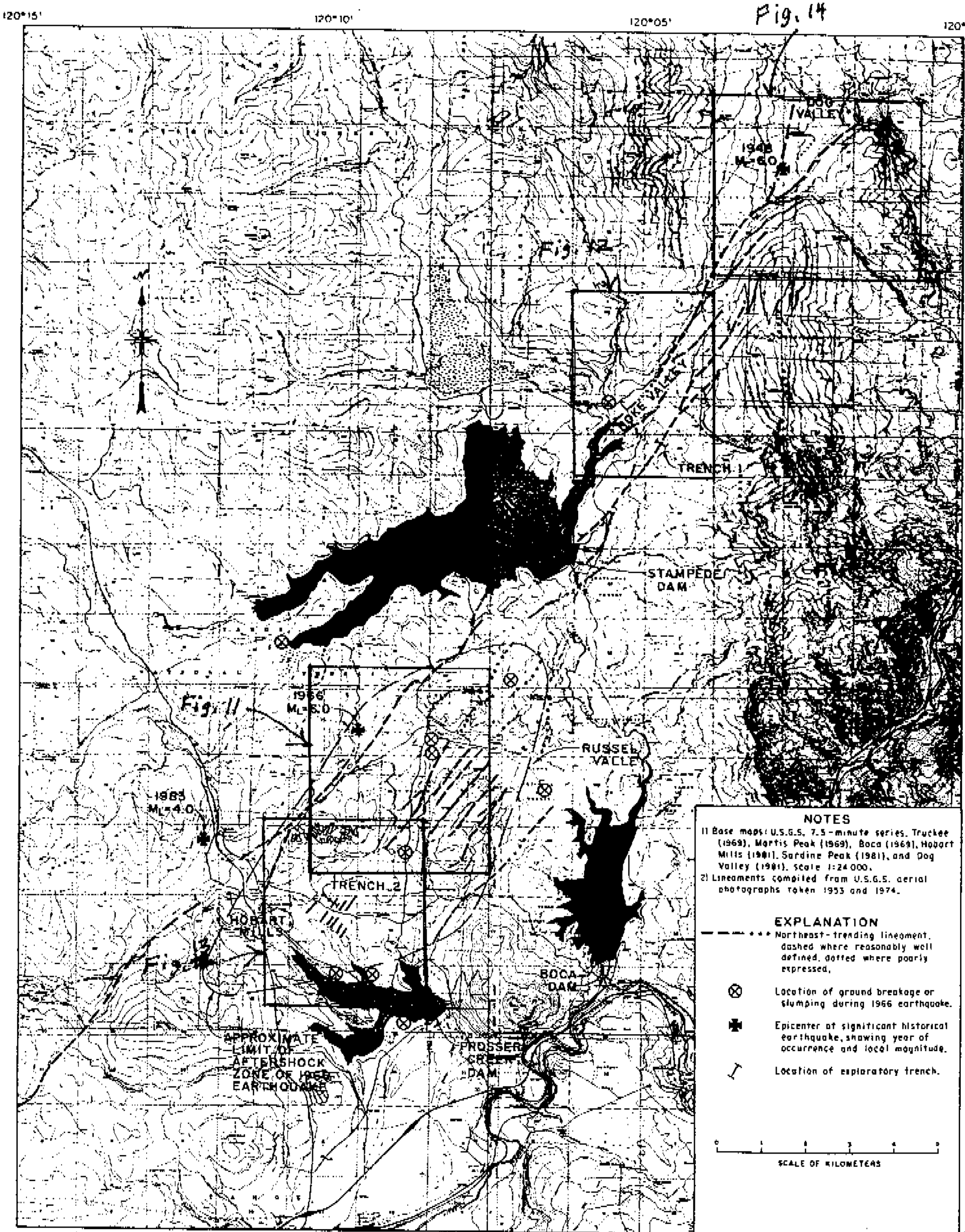
Figure 10 is a map of the Dog Valley fault prepared by Hawkins and others (1986). The entire length of the Dog Valley fault was field-checked in October 1989 by reconnaissance of key locations where USBR had performed field work. Both trench sites 1 and 2 were visited and photographed. Although the trenches had been backfilled, the geomorphic features in the immediate vicinity of each trench provided useful insight and field confirmation of the USBR report.

Russel Valley Area, Dog Valley Fault Zone

The unusual lineaments within the broad Dog Valley fault zone in the vicinity of Russel Valley are quite intriguing as viewed on stereoscopic aerial photographs. (Reference USDA flight 615170, photograph numbers 377-197 and 377-198 for Russel Valley.) Accordingly, a traverse was made of the Russel Valley area using available dirt roads to examine the lineaments. Refer to Figure 11.

Left-lateral deformation may be occuring in the Russel Valley area along the presumed trace of the Dog Valley fault, yet the inferred surface expression appears enigmatic and distributive over a broad zone about 2 km wide. The pattern repeats in about 8 to 10 small ridge-valley sequences oblique to Russel Valley.

The purpose of the October 1989 one-day reconnaissance was: (1) to search for vestiges of cracked ground reported by Kachadoorian and others (1967), (2) to search for subtle fault scarps along the margins of the long linear valleys, and (3) to review the possibility of geomorphic expression of bedrock petrofabric structure, bedrock lithology, or glacial deposits. There was no evidence of ground cracking remaining from the 1966 M_w5.9 earthquake. No fault scarps were observed. On the ground the lineaments are less



Map showing topographic lineaments along the Dog Valley fault, locations of significant earthquake epicenters, and trench locations.

Figure 10. Dog Valley Fault Zone
(from Hawkins and others, 1986)

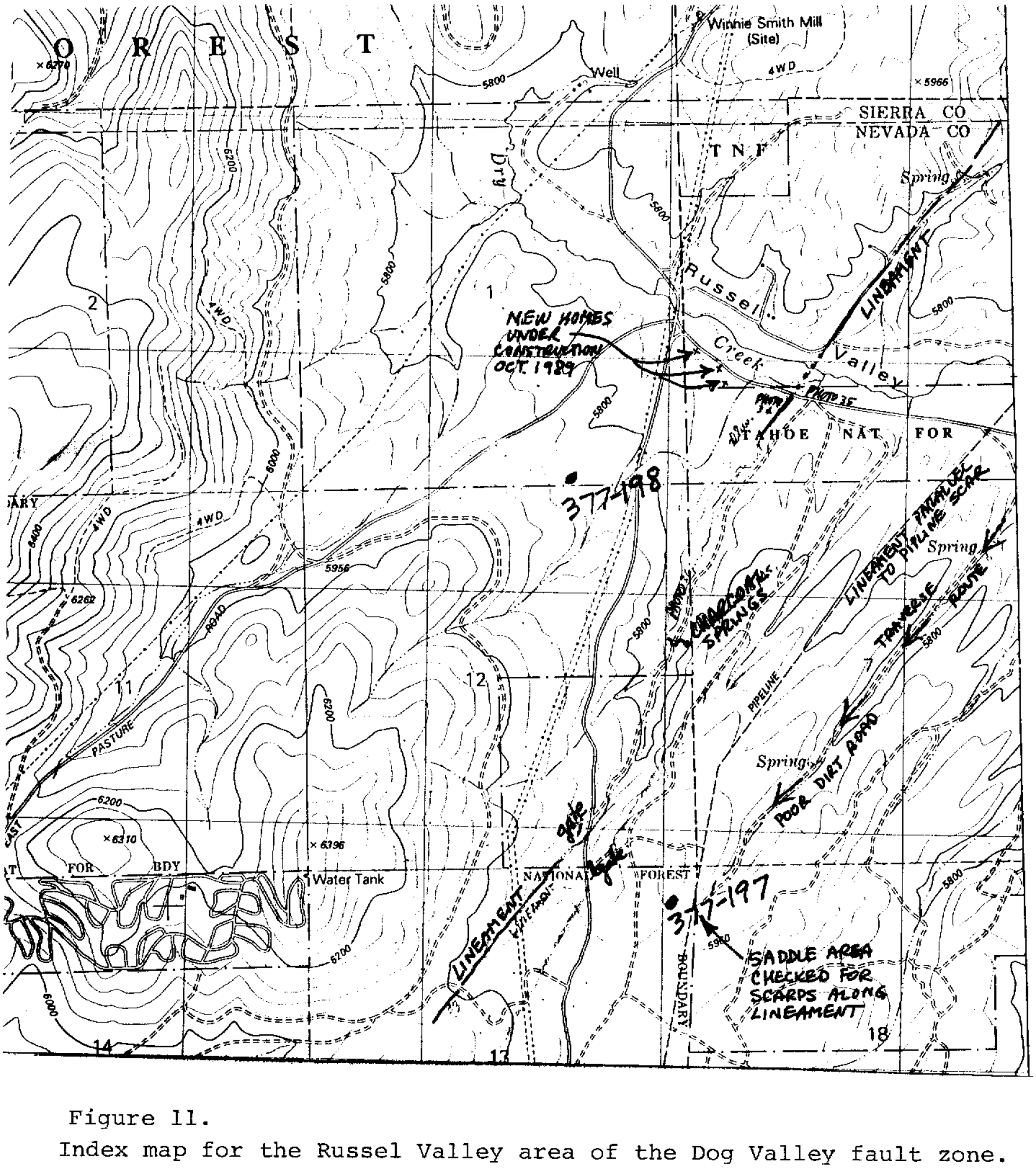


Figure 11.
Index map for the Russel Valley area of the Dog Valley fault zone.

Pronounced lineaments trending NNE cross Russel Valley at center-right on this map. This is the area which sustained wide-spread ground cracking during the 1966 M_w 5.9 Truckee earthquake, as reported by Kachadoorian and others (1967). No evidence of this ground cracking remains 23 years later, probably due to the influence of heavy winter snows. ~~Note photo taken at Charcoal Springs on following page.~~

profound, but remain somewhat enigmatic. There are virtually no bedrock outcrops in the Russel Valley area, so petrofabric (foliation or schistocity) information could not be obtained.

Several springs occur along the lineaments; it is inferred that their occurrence may be related to bedrock structure. An example is "Charcoal Springs" between Sections 7 and 12, about 2 km south of Russel Valley. (See Figure 11.)

In the Russel Valley area the fluvio-glacial soils of Pleistocene age are fairly loose clastic material; they contain cobbles, gravel, sand, and some silt, with a few scattered rounded andesitic boulders on the surface. The undulating northeast-trending valley and narrow ridge system appears to be tectonically controlled because of its repeated valley ‖ ridge ‖ valley ‖ ridge morphology parallel to the axis of the Dog Valley fault zone.

At the flank of each ridge and the edge of each elongate valley, there was an abrupt change in vegetation. The ridges are covered by sagebrush with scattered pine trees. The relatively flat alluvium supports grass. The alluvial areas may have been disked (plowed) by ranchers to remove sagebrush and to enhance growth of grass for stock grazing. Thus the lineament contrast seen on aerial photographs may be enhanced by sagebrush disking by ranchers. A similar man-made situation occurs in Section 7, where an airphoto lineament is enhanced by the graded scar of a large-diameter interstate gas pipeline.

USBR Trench 1, Hoke Valley area

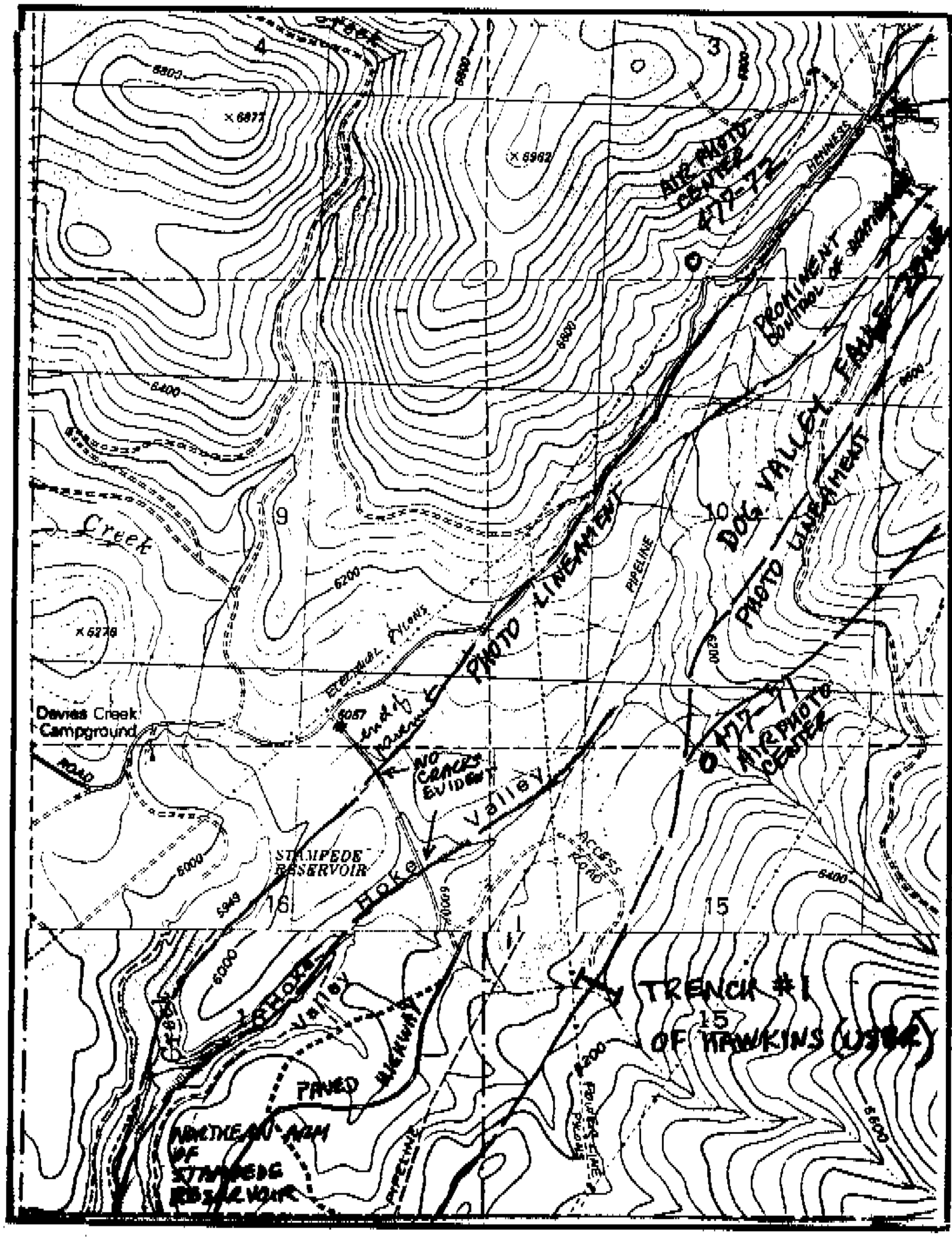
This trench site in Hoke Valley was visited October 8, 1989 to check the field relationship of the intriguing scarp reported there. Refer to Figure 12 for the trench location. Fault-related lineaments observed on stereoscopic aerial photographs in the Hoke Valley - Henness Pass area are partly "overprinted" by the construction scars of two parallel corridors of electrical pylons and one interstate gas pipeline. With the graded county road and the Dog Valley fault, there are a total of five lineal features trending northeastward through Henness Pass between Hoke Valley and Dog Valley. On the ground the geomorphic features are clearer than on aerial photographs for this segment of the Dog Valley fault.

USBR performed the trenching in September 1983, but the backfilled trench scar was still evident at the time of our October 1989 visit. (Refer to USBR Figure 5-3 for the trench log in Hawkins and others, 1986.) A small NE-trending scarp occurs in Holocene alluvium at this locality, but the scarp does not continue laterally across the adjacent hillslope. The scarp is confined to just the spring area across a tiny alluvial fan. We concur with the assessment of Hawkins and others (1986) that the young scarp is apparently due to spring-sapping and not tectonic surface displacement.

USBR Trench 2, east of Hobart Mills

About two kilometers east of Hobart Mills and just north of Prosser Creek Reservoir are a number of northeast-trending parallel swales. Refer to Figure 13. These swales are inferred to lie along the southern end of the Dog Valley fault zone. The most prominent swale was trenched by USBR in 1983; no evidence of surface faulting was found by them in the trench. Refer to Figure 5-4 of Hawkins and others (1986) for the trench log.

Nine swales in this area, along with the site of Trench 2 and nearby roads, were



Major drainage divide at Henness Pass. Six dirt roads diverge from here. All were checked.

(1981)
Dog Valley Quad

Boca Quad (PR69) 1955
note the lack of a precise splice because the quadrangles are of much different dates.

Figure 12.

Index Map to USBR Trench #1- Hoke Valley, Dog Valley fault zone
The trench site was visited October 8, 1989. Access by dirt road constructed to maintain pylons and right-of-way for electrical power lines. Logging operations were underway in the center of Section 15, but the original trench site was found because it was outside of the logging area. The backfill scar was clearly evident although the field trenching had occurred six years earlier (9/23/83).
A small scarp is present at this locality, but it is not evident on this 1:24,000 scale map. The scarp appears due to spring sapping rather than tectonic offset. More than a mile of the fault lineament was walked in the field, but there are no other scarps. Two lineaments cross the paved road in Hoke Valley. These were checked and no cracks were observed.

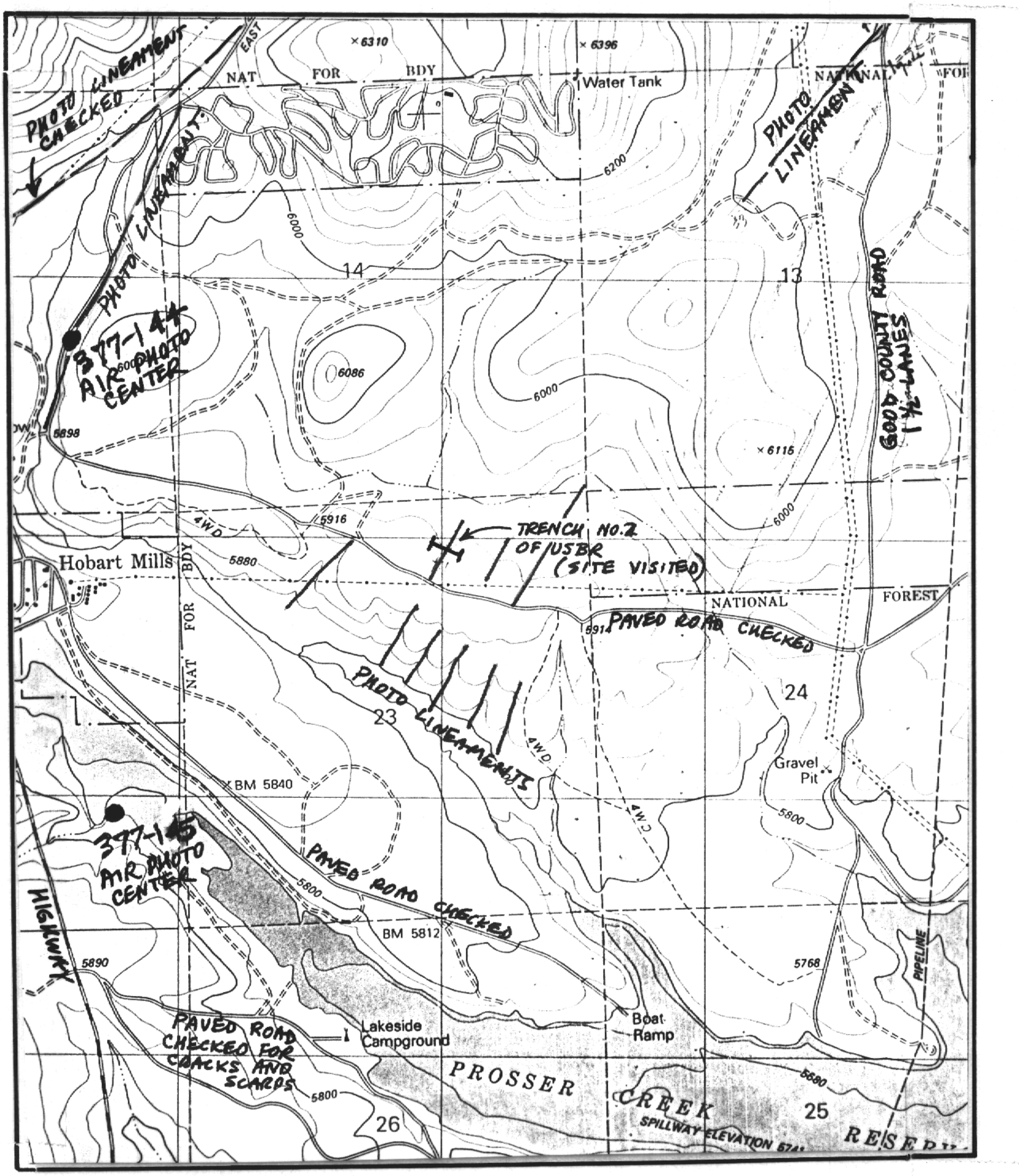


Figure 13.

Index Map of Prosser Creek Reservoir Area.
Photo lineaments are plotted on the 1:24,000 base map.
Air photo centers of two stereoscopic pairs are indicated by heavy dots. Notes indicate areas field checked in October 1989. Trench No. 2 of USBR (Hawkins and others, 1986) was ~~was~~ visited and the backfilled scar was still visible. No scarps or cracks of any kind were observed in this reconnaissance.

checked in October 1989. No scarps or cracks were found. The northeast-trending swales may possibly be controlled by the structure of the unseen bedrock.

Dog Valley Area, Dog Valley fault zone

The north end of the Dog Valley fault zone in Dog Valley proper is the epicenter of the 1948 M_L6.0 earthquake. The location of the epicenter is not well constrained, but Dog Valley appears to be the best estimate. A brief half-day reconnaissance was performed to search for fault scarps in Dog Valley. Refer to Figure 14. Several slope profiles were checked in Section 25 along the southeastern edge of Dog Valley, but no scarps were discerned. All of the basal slopes were smooth concave shapes with no inflection points. The alluvium in Dog Valley is tilted sharply eastward and the drainage of the valley exits in a narrow bedrock gorge on the east side. No evidence of faulting was seen in the Tertiary volcanic rocks at the mouth of the gorge on the east side of Dog Valley.

USBR Conclusions

Hawkins and others (1986, p. 152-153) conclude that these faults are seismically active: Genoa, Tahoe (east, west+north), Last Chance, Mohawk Valley, and Dog Valley. Maximum credible earthquakes for these capable faults range from M6¾ to M7½.

Their extensive field work did not indicate the presence of surface faulting along the trace of the Dog Valley fault, but they conclude that this is a Holocene-active fault based on the abundant seismic activity, especially considering the 1948 M_L6.0 and 1966 M_w5.9 earthquakes.

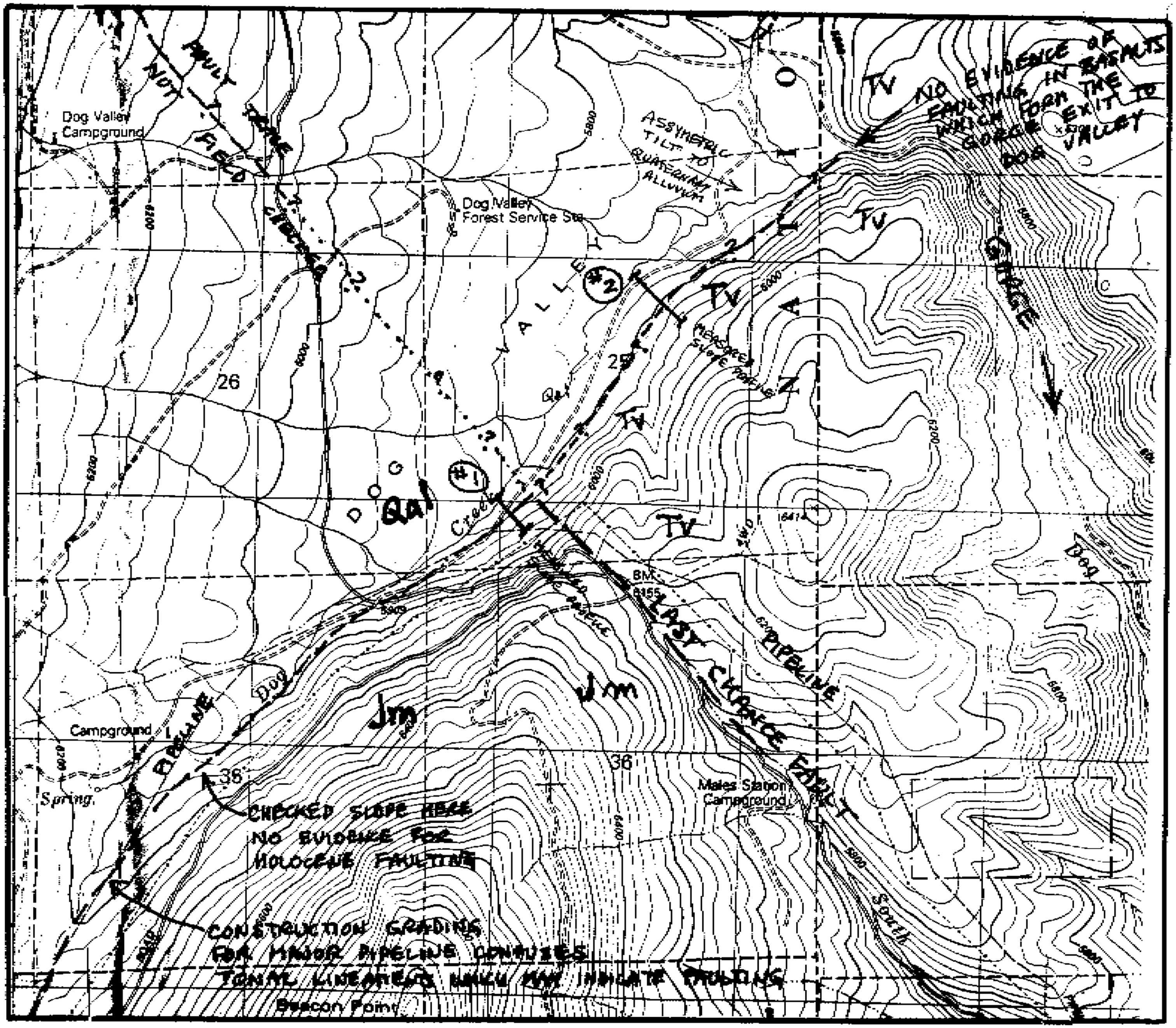


Figure 14.

Reconnaissance Index Map for the Dog Valley fault at its type locality in Dog Valley. Cross Sections 1 and 2 are located here.

The alluvium in Dog Valley is tilted towards the southeast, so that the stream flows nearly on the southeast side, parallel to the inferred trace of the Dog Valley fault.

A large-diameter pipeline and power lines have been constructed along the SW side of Dog Valley and parallel to the creek, so it is difficult to interpret aerial photographs in this area. No evidence of Holocene faulting was seen in the field although this definitely appears to be a Quaternary fault.

REGIONAL SEISMICITY

Figure 15 is a seismicity map of the Truckee-Tahoe area for the years 1920 through 1973. While some of the older epicenters may not be accurately located, this 53-year record stil conveys the relatively high level of seismicity for this region. Of particular interest are the 1948 and 1966 epicenters shown on Figure 15; these lie along the Dog Valley fault zone. Hawkins and others (1986, their Figure 4-4) prepared this map; 45 aftershocks of the 1966 Truckee earthquake were deleted for clarity.

Epicenters in the same Truckee-Tahoe area for the years 1973-1984 are shown in Figure 16. This epicentral data was gathered by a special high-resolution UNR/USBR network and many of the epicenters were relocated. The Dog Valley fault zone clearly continued to be seismically active. The relative level of seismicity of the "North Tahoe fault" and the "West Tahoe fault" appears less, with earthquakes mostly on the east (Nevada) side of Lake Tahoe.

A geophysical investigation of the northern Sierra Nevada - Basin and Range boundary was undertaken by Martinelli (1989) as a master's thesis at the University of Nevada at Reno. This work is a thorough study of the regional seismicity and regional geologic structure of the Tahoe area.

It has long been an intriguing question: exactly where is the western edge of the Basin and Range Province and where is the eastern edge of the northern Sierra Nevada? It is a complicated answer. The "West Tahoe" fault, stepping over to the Donner Pass fault, stepping over to the Mohawk Valley fault is the boundary postulated by Martinelli (1989) based on regional seismicity and structure. Refer to Figure 3. According to her model, the Dog Valley fault is not a major province boundary, but enigmatically it remains the most seismically active fault in the region based on the limited instrumental record of the past several decades.

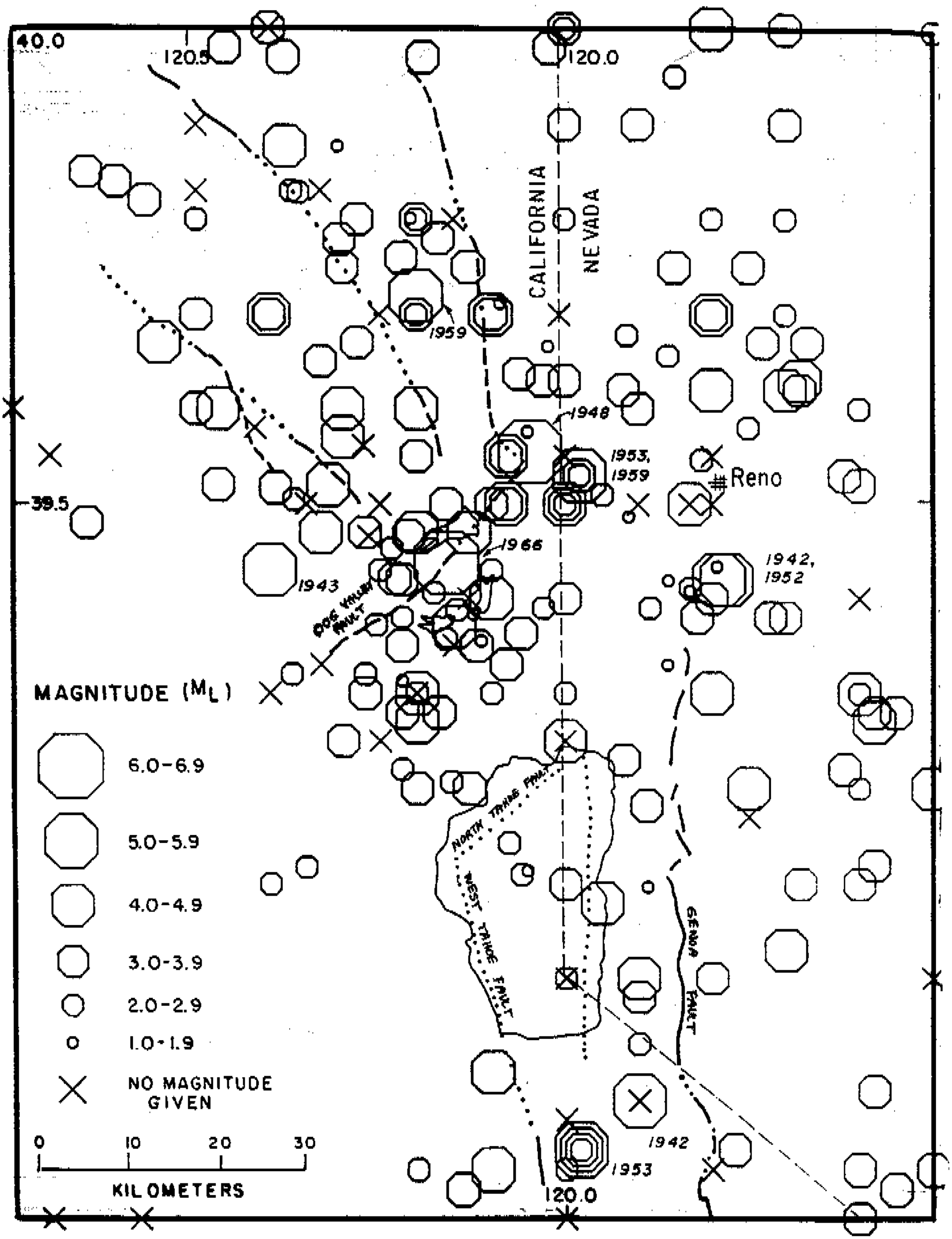


Figure 15. 53-Year Seismicity Record from 1920 to 1973.
Data from UCB and UNR catalogs. 45 aftershocks of the 1966 Truckee earthquake were deleted for clarity. (From Figure 4-4 of Hawkins and others, 1986)

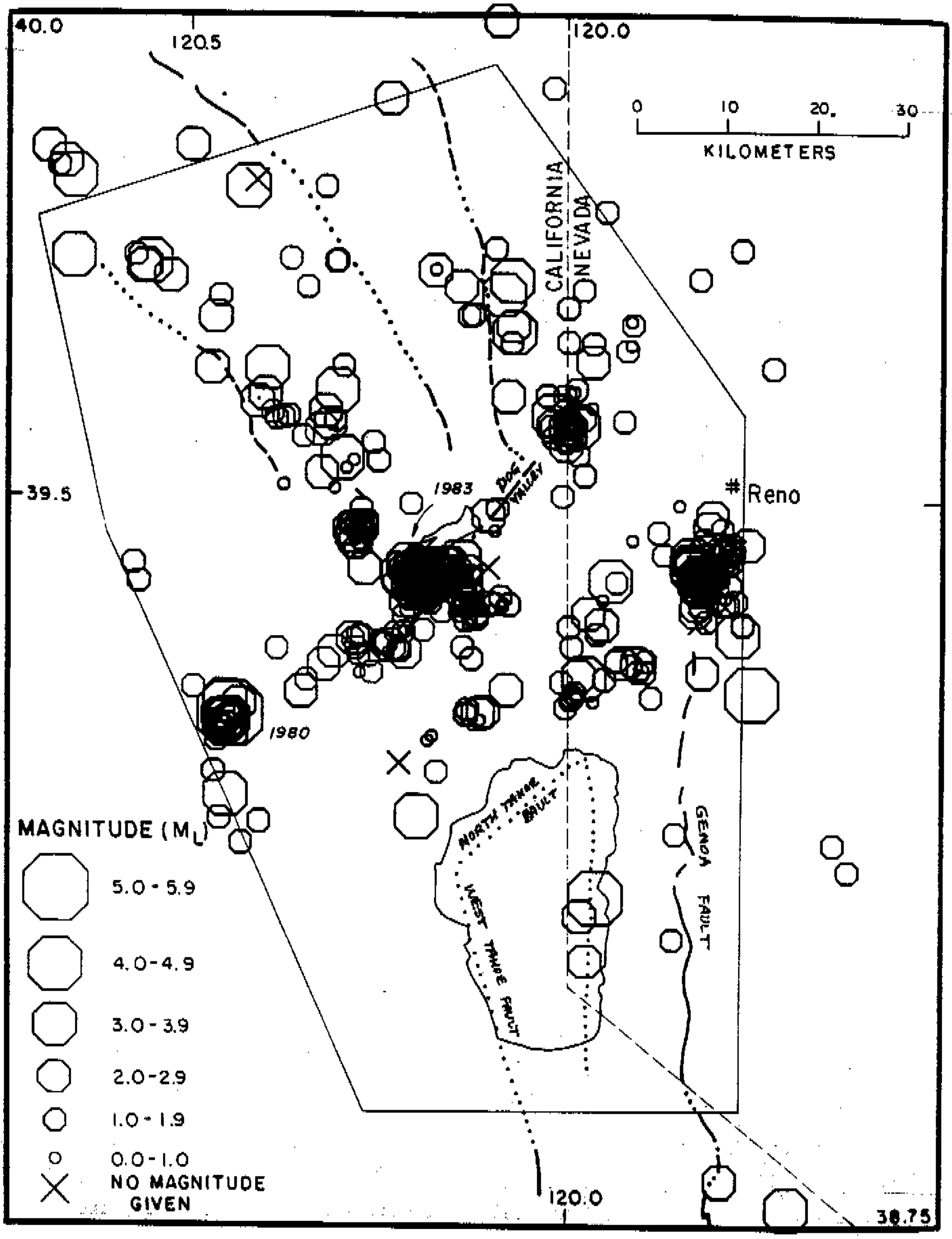


Figure 16. Seismicity of the 11-year period 1973 through 1984.
Note relatively higher seismicity of the Dog Valley fault zone than the faults of Lake Tahoe. (From Figure 4-5 of Hawkins and others, 1986).

CONCLUSIONS AND RECOMMENDATIONS

Most of the study area has a relatively high potential for damaging earthquakes based on historic seismicity, yet Holocene expression of the surface faulting remains enigmatic and not well defined.

Much of the deformation in the Truckee - Tahoe area appears to be less than 2 million years old, and probably late Pleistocene to possibly early Holocene in age. Fault scarps of definite Holocene age appear lacking, but many may be obliterated or subdued from the influence of heavy snow cover (2-5 m) each winter. Thick colluvial soils, which are so revealing in neotectonics studies in the California coast ranges, are of limited development in the Truckee area. Instead, the Pleistocene glacial deposits have immature or poorly developed soils at best. Optimum conditions to preserve faulted Quaternary regolith are unfortunately lacking in most Truckee localities.

Dog Valley Fault

This is a seismically active fault, as evidenced by earthquakes in 1948 (M_L6.0) and 1966 (M_W5.9), as well as active microseismicity.

The 31-km long fault trends about N44°E and dips near vertical (±80°SE) according to the distribution of aftershocks. The surface trace appears to be distributive along several northeast-trending structurally controlled lineaments in the vicinity of Prosser Reservoir and Stampede Reservoir. Contemporary seismological data indicate left-lateral strike-slip displacement. This is supported by regional topography for its central and southern portions, although the steep relief (≈200 m) on the northern portion (in Dog Valley proper) may indicate a significant component of vertical displacement for the northern end of the fault. The slip rate and mean recurrence interval for earthquakes are not known from geomorphic evidence.

The expression of surface faulting is not well enough defined for zoning under the Alquist-Priolo Act based on currently available field evidence. Even if the full width of the corridor of cracked ground found by Kachadoorian and others (1967) were zoned, it is believed that the fault trace would not be found by diligent fault trenching at any particular building site. This is the principal reason not to zone the Dog Valley fault at the present time.

Unnamed "Fault No. 2", west Martis Creek area

This appears to be a late Pleistocene to early Holocene fault based on mapping by Franks (1980). It is not sufficiently active nor well enough defined on stereoscopic aerial photographs to zone at the present time. Additional reconnaissance field work is suggested for this fault because of the potential for rural residential development in the Northstar area.

Unnamed fault near the Joerger Ranch.

This fault on the east side of Martis Valley is probably late Pleistocene in age based on evidence at its northerly end. This fault forms the structural boundary on the east side of Martis Valley. It is not recommended for zonation at the present time because the fault zone appears not well enough defined to meet current criteria.

Unnamed fault near Dollar Point.

There is no evidence of a Holocene scarp on the landward portion of this fault, but there is some evidence of active faulting from the lacustrine seismic reflection record. This is an enigmatic relationship. Defer zoning at the present time and reserve judgement.

Unnamed fault near Tahoe Vista.

A fault-bounded horst-like structure has been mapped between Tahoe Vista and the Brockway Golf Club by J.L. Burnett (unpub. CDMG ozalid map). The hill is composed of Tertiary andesite. The faults are only about 1 km in length and trend northwestward. All of the paved residential roads which circle the hill were checked for cracks and scarps. The faults are inferred to be of late Pleistocene age. There are no fault scarps evident in the field. No zoning is recommended.

Unnamed fault near Kings Beach.

Field evidence for Holocene activity is lacking along this small horst-like structure. It is inferred to be of late Pleistocene age. No zoning is recommended.

"North Tahoe" fault

This major structural fault appears to cut Holocene-age silty sediments in Lake Tahoe, but there is no landward exposure of the fault on the California side of Lake Tahoe.

At the present time, sub-lacustrine Holocene-active faults have not been zoned under provisions of the Alquist-Priolo Act. The text of the Alquist-Priolo Act appears to restrict its application to structures for human occupancy (on land).

"West Tahoe" fault

This major boundary fault is believed to be Holocene active because it cuts Holocene-aged sediments. The fault is seismogenically capable of producing a ~M7 earthquake. The reasons against zoning it are essentially the same as for the "North Tahoe" fault.

Recommendations

1. Do not zone the Dog Valley fault, based on our current perception of its equivocal and poorly-defined surface expression.

2. Do not zone any of the late Pleistocene faults in the Martis Valley area south and east of Truckee.

3. Do not zone the "North Tahoe" fault and the "West Tahoe" fault at the present time because these Holocene-active faults are entirely concealed by the waters of Lake Tahoe and there are no landward portions of these fault zones.

Report reviewed; recommendation to not zone is approved. Earl W. Hart 4/29/92

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